CONTROL SYSTEM FOR THE RIKEN ACCELERATOR RESEARCH FACILITY AND RI-BEAM FACTORY

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Abstract

The control system of the RIKEN Accelerator Research Facility (RARF) has been completed in the summer of 2002 using the Experimental Physics and Industrial Control System (EPICS) [1] and the basic operations of RARF are currently carried out without any serious problems. For more stable beam operation and system expansion gazing at the RIKEN radioisotope (RI) Beam Factory (RIBF) [2] control, we have carried out many improvements of it. In this paper, we will report the two latest improvements. One is development and introduction of our original control device, Network-Device Interface Module (N-DIM), and the other is employment of the Pipeline CAMAC Controller with PC104plus Single Board Computer, CC/NET [3][4], to our control system. Both improvements were applied for taking measures to meet the difficult situation to keep on using our old CAMAC control system in the future.

CONTROL SYSTEM OF RARF

The structure of the RARF control system is shown in Fig. 1. The part which consists of the HP-UX server computer, the database server computer and five VME single board computers is our first and main system. When we employed EPICS as a substitute of the previous control system, we replaced only high-level control part by taking into consideration the fact that the RARF is in operation and so as not to significantly influence the RARF operation. The HP-UX server computer is used as an Operator Interface (OPI), and EPICS base R.3.13.8 has been running on it. VMEs are used as Input/Output Controllers (IOC). The database server is based on the Oracle software system, and it manages all accelerator system data of RARF components such as a name of device, a control address, and a specification. OPI communicates with IOCs through the Ethernet using the Channel Access (CA) protocol.

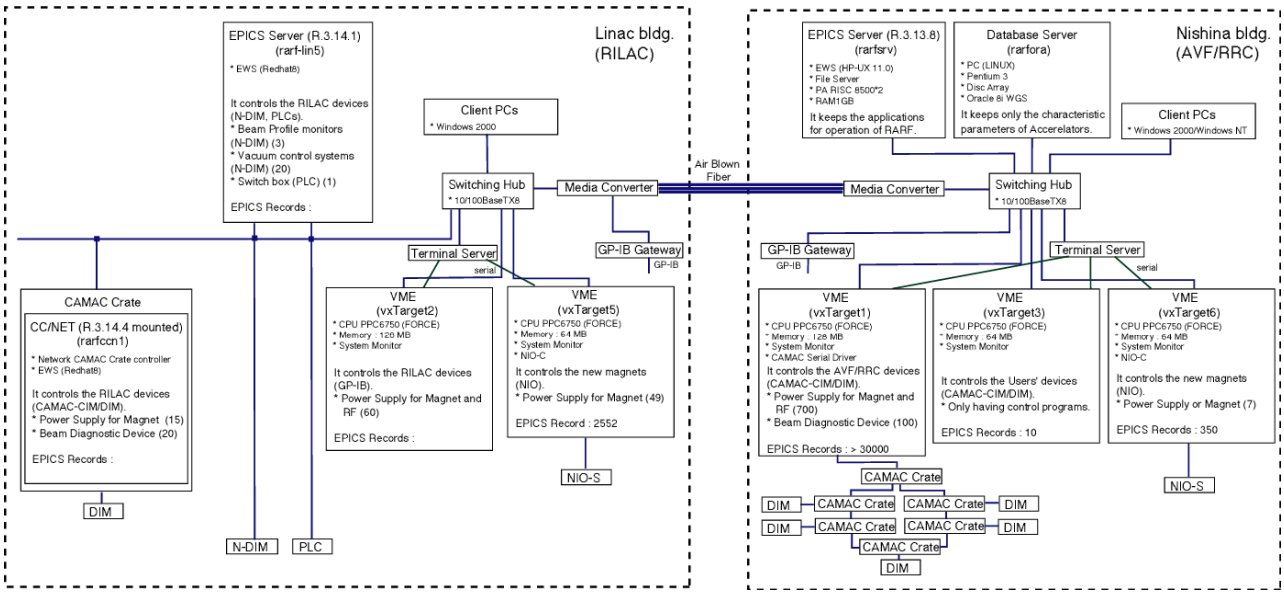

Figure1. Structure of the RARF Control System

As a main feature of our control system, it is based on a CAMAC serial crate network and is supported by two types of modules; communication interface modules (CIMs) and device interface modules (DIMs). These modules were originally developed by RIKEN about twenty years ago in order to assist the main computer in its tasks. CIM is a CAMAC module which has twelve pairs of serial I/O ports, and it executes the message transfer between the VME and DIM. DIM has 32 DI/DO ports and 16 AI ports, and it executes a local sequence control, local surveillance, function generation and testing. Information is transferred serially between these two modules through a pair of plastic optical fibre cables. Almost all magnet power supplies and beam diagnostic devices are controlled by them.

SYSTEM EXPANSION TO RIBF

The system expansion of RARF has always been required for the RIBF. New components have been introduced into the cases such as the upgrade project of RILAC, renewals of very old components and so on. On the occasion, there is a demand that the expansion of the control system should be carried out as simple as possible. One solution is that we control those components by using the CAMAC-CIM/DIM system as well as the existing ones.

On the other hand, in investigation of a control system of the RIBF, it may be the easiest solution to expand the current system to the next one because the RIBF is a cyclotron facility as well as the RARF. However, CAMAC interface has already become old and it is not a good idea to employ such old one for the control of new components. Then it was decided to introduce three types of new control interfaces into the EPICS control system.

The first one is the NIO interface [5], which is used for new magnet power supplies. All magnet power supplies in RIBF will be controlled by NIO instead of CAMAC-CIM/DIM. In the RARF, we have already controlled the power supplies with NIO in the extended beam line of RILAC without any serious problems. The second one is PLC, which is used for a new RF system and so on.

The third one is N-DIM. It is our original control device developed to substitute for the CAMAC-CIM/DIM system. In the RIBF control system, N-DIM is used for a various purpose; to control all beam diagnostic equipments, all vacuum systems, and driving systems for deflectors and so on. More than one hundred N-DIMs will be used to control them. Table 1 shows the relation between an interface device and a component of RARF and RIBF.

Table 1. Interface Devices in RARF/RIBF

	RARF			RIBF						
	RILAC	AVF/RRC	BT (existing)	fRC	BT (in Nishina)	BT (in new building)	IRC	SRC	Injection Line for Big-RIPS	Big-RIPS
Ion Source	Hard wire /WE 7000 (Yokogawa)	WE 7000 (Yokogawa)								
RF	PLC (Omron)	PLC (Sharp)	DIM	PLC (Omron)	not fixed	not fixed	PLC (Omron)	PLC (Omron)		
Magnet Power Supply	GP-IB/NIO/DIM	DIM	DIM/NIO*	DIM/NIO	NIO/DIM	NIO	NIO	NIO	NIO	NIO
Beam Diagnostics	DIM/N-DIM	DIM	DIM	N-DIM/DIM	N-DIM	N-DIM	N-DIM	N-DIM	N-DIM	not fixed
Driving Controller	DIM	DIM	DIM	N-DIM/DIM	N-DIM	N-DIM	PLC (Omron) /N-DIM	PLC (Mitsubishi) /N-DIM	not fixed	not fixed
Vacuum	N-DIM	PLC (Omron)	DIM	Local only	N-DIM	N-DIM	PLC (Omron)	PLC (Mitsubishi)	N-DIM	not fixed
Beam Interlock	Hard wire /PLC (Mitsubishi)	DIM	DIM	not fixed	not fixed	PLC (Mitsubishi)				
Cooling	Local only	Local only	Local Only	Local only	Local only	PLC (Mitsubishi)				

: controlled by the existing EPICS system

: will be controlled by the expanded existing EPICS system

* NIO : Network-I/O (NDS)

Development of N-DIM

For measuring a beam in RIBF, we improved the beam diagnostic hardwares to fit a high energy and high intensity beam. However, the basic driving mechanism is same as the equipment used in the RARF. Thus, we had to develop a control device like the CAMAC-CIM/DIM to control them. NIO was a candidate of it and we examined its performance. However, it was developed specially for magnet control and it was difficult to convert it like the CAMAC-CIM/DIM. On the other hand, PLC is another candidate of the control device and it can be used instead of the CAMAC-CIM/DIM, however, the cost to compose the system becomes high. Considering these facts, we have started to develop our original device substitute for the CAMAC-CIM/DIM system since three years ago, and we named it N-DIM. The important features of N-DIM are as followings;

- N-DIM is a network-based intelligent controller.
- Each N-DIM has an IP address.
- Each N-DIM controls a beam equipment such as a beam profile monitor.
- N-DIM plays roles both a server and a client in the control system.
- Control commands are written in ASCII code.
- N-DIM is a radiation-resistance device.

Its more detailed characteristics are shown in Table.2.

Table 2. Main characteristics of N-DIM

CPU	SH4 (HITACHI)
memory	6MB (S-RAM), 1MB (EP-ROM)
OS	μ ITRON 2.0
protocol	TCP/IP, UDP/IP
service	FTP, Telnet
port	10/100Base-T, RS-232C
power supply	5V/1.5A, 24V/1A (for I/O)
size	320(W) x 210(D) x 30(H)
I/O	DI : 32 (Isolated)
	DO : 32 (Isolated)
	AI : 16
	another DI : 8 (Isolated)

Control of N-DIM

As shown in Table 2, N-DIM has a CPU on it and the CPU has about thirty kinds of the original control commands and their programs. Any computer can communicate with N-DIM through TCP/IP and UDP/IP. Thus, we developed the software to control it with the control group of KEK [6]. One remarkable feature of this software is that it can work both on EPICS base R.3.13 and R.3.14 by the common program. We newly introduced the latest version of EPICS base at that time, R.3.14.1, into our control system last year, and it is running on a new Linux server PC whose OS is Redhat 8 as shown in the left part of Fig. 1.

We have tried to use N-DIMs in the existing EPICS control system since last summer for checking its performance. In the status, we can control about twenty vacuum systems and twenty beam profile monitors in the RILAC.

MAINTENANCE OF RARF CONTROL SYSTEM

Introduction of CC/NET

As mentioned in the abstract, the basic operations of RARF are currently carried out without any serious problems. However, our control system includes one fundamental problem; a photo transceiver module in the U-Port Adopter, which is an essential CAMAC module to construct our system based on a CAMAC Serial HWY loop, is no more available. It means that it will be difficult to keep on using the current CAMAC-CIM/DIM system when a U-Port Adopter will be out of order. Thus, we have been investigating about a future structure of the CAMAC-CIM/DIM system. Since N-DIM has compatibility with it, it is possible to use N-DIM in the RARF control system instead of the CAMAC-CIM/DIM. In fact, there is a plan to replace them in the RILAC with N-DIM gradually. However, it is difficult to replace all CAMAC-CIM/DIM in RARF to N-DIM because of following three reasons. The first reason is that it becomes too costly because there are too many DIMs in the RARF. We are using about 170 DIMs for RARF control. The second reason is the situation that RARF is in operation. The last reason is that the existing control commands in N-DIM are prepared to control only beam diagnostic equipments such as a beam profile monitor. Therefore, we have to develop control commands from scratch when we replace the control system from the CAMAC-CIM/DIM to N-DIM. It is not easy for us. Thus, we had investigated the way to support the CAMAC-CIM/DIM system in the future, and we decided to employ the CC/NET as the other improvement to maintain our old CAMAC-CIM/DIM system in RARF.

The important features of CC/NET are as followings;

- CC/NET is a network-based intelligent controller.
- System disk : flash disk (512 MB)
- OS : Debian/GNU Linux (kernel version 2.4)
- Includes original device driver and library

According to the first feature, we can replace CAMAC Serial HWY loop with Ethernet by using CC/NET, and we can keep on using CIM/DIM system in the future. In concretely, we can remove a U-Port Adopter and CAMAC Serial HWY loop from our control system and control the CIM/DIM system through the Ethernet directly from a high-level control system by using CC/NET instead of a former CAMAC crate controller as shown in Fig. 1.

Control of CC/NET

Since Debian/GNU Linux is running on CC/NET, CC/NET can play role of a high-level control system, too. We installed EPICS R.3.14.4 on it. The control software of CC/NET was developed with the control group of KEK as well as the N-DIM control software. We derived it from the existing software, camacLib.c, in EPICS R3.13, and developed a wrapper over the CC/NET driver from TOYO to provide ISONE Standard CAMAC APIs to be able to use our original EPICS CAMAC-CIM/DIM device support as well as the standard EPICS CAMAC device support without major change. There is no difference between the former CAMAC-CIM/DIM system and CC/NET-CIM/DIM system in the OPI layer such as GUIs for beam operation.

SUMMARY

As the latest improvement of our control system, we introduced N-DIM and CC/NET, and we can control them without any serious problems. As a next step, we have following plans;

- Control Faraday cups by N-DIM.
- Replace another CAMAC-CIM/DIM system of RARF to the system using CC/NET.

REFERENCE

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